

We are IntechOpen, the world's leading publisher of Open Access books Built by scientists, for scientists

5,600

Open access books available

137,000

International authors and editors

170M

Downloads

Our authors are among the

154

Countries delivered to

TOP 1%

most cited scientists

12.2%

Contributors from top 500 universities



WEB OF SCIENCE™

Selection of our books indexed in the Book Citation Index
in Web of Science™ Core Collection (BKCI)

Interested in publishing with us?
Contact book.department@intechopen.com

Numbers displayed above are based on latest data collected.
For more information visit www.intechopen.com



Predictive 3D Modelling and Virtual Reality of the World Cultural Heritage of Ruins of the Buddhist Vihara at Paharpur, Bangladesh

Md. Masood Imran and Miner Masud

Abstract

Generating predictive 3D modelling and virtual reality (VR) of the World Cultural Heritage of ruins of the Buddhist vihara at Paharpur, Bangladesh, is the ultimate notion of this research paper. In Bangladesh archaeology, it is a new paradigm to generate the predictive 3D models of the ruined structures in real mood and develop a VR to organise a journey from ruins mood to near to real mood. It will help to forecast the past virtually through the journey of present towards past. Futuristic forecasting is the normalised phenomenon in statistical analysis, despite the archaeologist's motto, which is to predict the past. Methodologically, philosophising the vihara architecture of the Bangla region by following Vajrayana Buddhism is the first step. Then, information technology and archaeological data enable the 3D model generation of a known structure, producing high-quality outputs of the historic site for digital conservation. Finally, 3D predictive modelling has been achieved by supporting the integrated and interactive consideration of data, established 3D modelling and VR generating tools, and the guidance of the London Charter of 2006 and the Seville Principle of 2011 for the regenerating of the cultural heritage of ruins of the Buddhist vihara at Paharpur, Bangladesh.

Keywords: digitalisation, cultural heritage, predictive 3D modelling, virtual reality, Paharpur

1. Introduction

Seven century's *Somapura Mahavihara* was listed as world heritage under the title of "ruins of the Buddhist Vihara at Paharpur, Bangladesh" by UNESCO in 1985 AD. The ruin of Paharpur Vihara is located at Naogan District, Rajshahi Division in Bangladesh. This vihara was known to the heritage residents as a hill in Bangla as *Pahar*. Because it was totally buried before archaeological exploration (1807–1812: Buchanon Hamilton, under the survey in Eastern India between [1]) and excavation in the last half of the 18th century to the first half of the 19th century. It was unfolded step by step through the excavations (1879 to 1932) [2] and visible as a vihara with a central shrine. It comes out with series of terracotta

plaques. Based on the ground plan, it has been characterised as a Mahavihara. However, a debate has been raised among the excavators and later researchers about the predictive stylistic pattern of the central shrine. The dominating ideas are cruciform style, *chaumukha* Jain temple, *Sarvatobhadra* style, and *Vajrayana* Style [3]. Nevertheless, these stylistic forms failed to predict the perspective of this shrine.

These days, there are number of software have been developed to generate 3D predictive modelling (e.g., [4]), visualisation, and digital conservation through virtual reality (VR) (e.g. [5]). It can be considered as a known to unknown journey of cultural heritage. Following the London Charter of 2006 and Seville Principles of 2011 are followed to generate the 3D predictive modelling and VR for visualisation and digitally preserve the world’s cultural heritage of the Buddhist Vihara of Paharpur. The norms of digitalisation of cultural heritage have not been officially initiated by UNESCO, and ICOMOS did not ratified it by the general assembly [5]. Therefore, the London Charter of 2006 and the Seville Principle of 2011 are widely accepted to digitalise the cultural heritage, which also been followed to systematise this research.

The essence of this initiative, particularly for generating predictive 3D modelling of Paharpur Vihara or *Somapura Mahavihara* is: First, philosophising the vihara architecture of the Bangla region by following the *Vajrayana* Buddhism. Second, information technology and archaeological data enable the 3D model generation of a known structure, producing high-quality outputs of the historic site for digital conservation. And third, predictive 3D modelling can be achieved with the support of the integrated and interactive consideration of data and the guidance of an established methodology for the regeneration of cultural heritage.

2. Archaeological history of Paharpur: A world cultural heritage

Paharpur has been archaeologically identified as *Somapura Mahavihara*, the most important early medieval archaeological site of Bangladesh (see **Figure 1**) [2]. Located in the northwest part of Bangladesh in the Upazila of Badalgachi and the district of Noagaon, Paharpur is listed as a World Heritage Site of UNESCO [7]. It

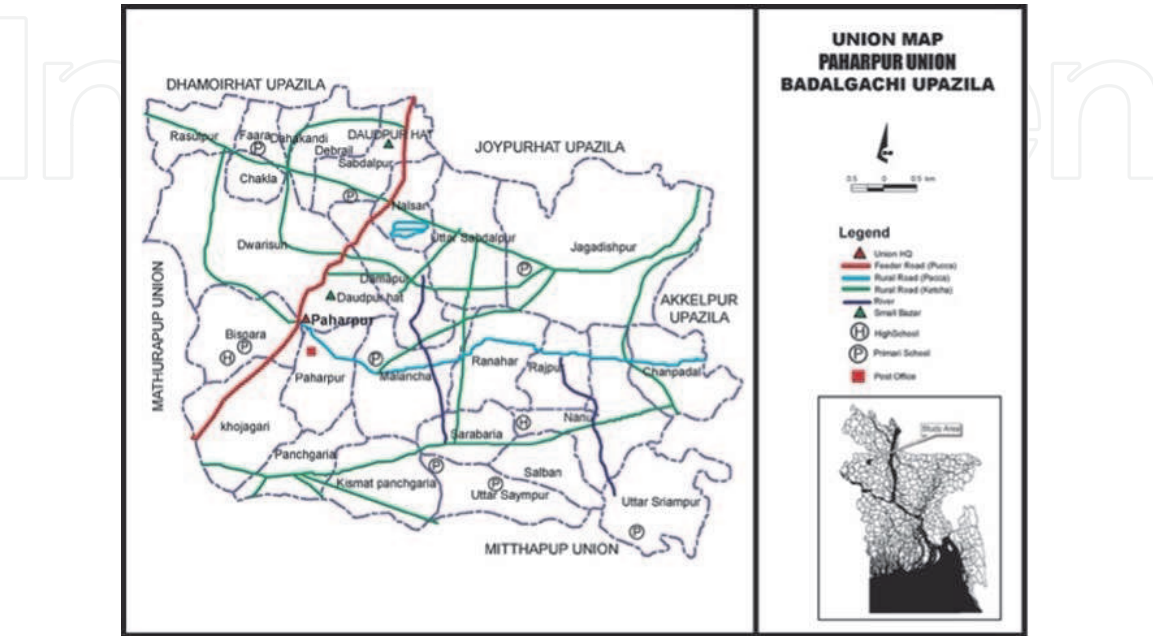


Figure 1. Geodetic position of Paharpur [6].

also contains the great Buddhist period depictions in Bangla, which is widely acclaimed along with Mahasthan, Bogra, and Maynamati, Comilla. According to Dikshit [8], a long period had already passed since it was finally left abandoned at the beginning of the 13th century. From the early 1930s, it received much attention in the historical and archaeological studies, in the selection and construction of past, in image and imaginary making project of the colonial and modern nation-state. Since it had been first excavated by eminent archaeologist Dikshit and his team in the early 1930s, this site has been re-excavated and repaired partially in phases [2].

The square-shaped Mahavihara can be seen in **Figure 2**, where every wing is 281 m in length. The Pala dynasty, notably, Dharmapala (781–821 AD), the second Pala ruler, established this *Shomapura Mahavihara* in Pharpur. There is speculation that this Mahavihara was reconstructed twice by the Pala descendants [2]. The monastery contained a thick exterior wall and two entrance provisions. These entrances were installed on the north and east wings. Each wing has continuous cells with a running corridor. Solid pedestals contain a couple of cells in each wing. The middle position of a few of the cells in three wings, except at the northern side, includes a small worship point. Except for the southern part of the monastery, every worship point is connected straight to the courtyard through the staircase. The Yantra Vajrayana styled central shrine is spatially positioned at the centre point of the open courtyard.

The central courtyard contains various small-scale and different structures such as, at the southeast corner structures, a group of five votive stupas or *panchavede*, kitchen, wells, votive stupas, a miniature architectural model of the central shrine. There is almost a lack of structures in the western half of the courtyard.

The fragments of sculptures, potsherds, ornaments, coins, seals, sealings, votive stupas salvaged are a fair number from these cultural heritage sites. From 1807, 1812, and 1879, under the reign of the British Empire, there were a couple of field explorations, and archaeological excavations were carried out by the high professional British officers, e.g., Buchanon Hamilton, Westmacott, and Sir Alexander Cunningham [2]. They have collected so many artefacts and preserved those in Kolkata Museum in India. In addition, the Varendra Research Museum of Rajshahi preserved a couple of artefacts by Saratkumar Ray, *Zamindar* of Balihar. Akshay Kumar Maitreya was a practising lawyer and a distinguished modern historian of Rajshahi, and Rama Prabha Chanda was a prominent historian and produced art and archaeology [2]. They took some preventive measures. Paharpur was declared as a



Figure 2.
A bird's eye view of the Paharpur (Google earth, January 2018).

protected archaeological site in 1919 under the Ancient Monuments Preservation Act of 1904 [7].

In 1923, a joint excavation was started by the Archaeological Survey of India, Varendra Research Society of Rajshahi, and University of Kolkata. The excavation initiated under Professor Dr. Bhandarkar of ancient history and ex-superintendent of Archaeological Survey of India. He conducted the excavation from 1925 to 1926 in the northern part of the central mound. After his archaeological activities, KN Dikshit commenced the next session from 1926 to 1927 and 1930–1932. GC Chandra conducted excavations from 1932 to 1934. After that time frame, Paharpur became a part of Pakistan, and Rafique Mughal excavated the monastic cells of the east wings. As an independent state of Bangladesh, after 1971, the Department of Archaeology began excavations in different phases, within 1981–1982, 1984–1985, 1988–1989, 1990–1991, and 2007–2008 [2].

The clay seals revealed the historical connections among Shri-Somapure-Shri-Dharmapaladeva-Mahavihariyarya-bhiksu-sangghasya. Taranatha and other Tibetan sources state that it was built by Devapala. As the Pala rulers were devout Buddhists, an inscription on the pillar found in the central shrine was inscribed with the name of Bhiksu Ajayagrabha, who was identified with the Pala Dynasty. He was a worthy successor of Devapala. The data was crosschecked with the Jagjivanpur copperplate, where the same name was found inscribed. This can be taken as proof that the monastery received continuous patronage from the Mahendrapala. Tibetan writings, especially, *Pag Sam Jon Zang* wrote that the monastery was repaired and renovated under the reign of Mahipala from c995–1043 AD.

The Nalanda inscription of Vipulashrimitra showed that the *Somapura* as *Mahavihara* flourished around the 11th century AD. The *Vangla* army of the Varman rulers of Vanga destroyed the monastery by fire. Vipulasrimitra established a *Tara* temple and restored the former glory of the Vihara by renovation works.

3. Conceptualisation of predictive 3D modelling and virtual reality

In statistical analysis, predictive modelling is related to data mining, and it forecasts the probability of outcomes. This forecasting always depends on several predictors to understand the future move. It is a futuristic prediction format despite the archaeologist's motto, which is to predict the past. Usually, an archaeological predictive model is a map, that indicates the relative potential of encountering an archaeological site. Primarily, predictive location models were attempted to locate and identify the pattern of distribution of archaeological records. In this research, the ruins of *Somapura Mahavihara*, popularly known as a Paharpur World Heritage, are anticipated through a 3D model and generating virtual reality by using the existing archaeological and technological knowledge.

Specific initiatives were made under this study, to save the world heritage, predict the 3D modelling, and represent the world cultural heritage by VR. It is argued that digital technology is essential to visualise the unknown past for it to be known. Technologies and techniques are getting updated daily, and archaeologists may quickly grasp these valuable techniques and tools to establish their hypothesis. It is very unusual to find in situ archaeological records. In most cases, fragmented and ruined archaeological records have been dug out. In this case, typo-technology and spatiotemporal reality have only been imagined hypothetically. The 3D modelling tools help to make this virtually real. It is virtual reality that was used to visualise the predictive 3D models of ruins of the vihara at Paharpur. This structure is well preserved and renovated by the Department of Archaeology, Ministry of Cultural Affairs, People's Republic of Bangladesh.

The 3D models of the present can feature architectures, monuments, and artefacts, making it possible, to generate the predictive 3D models to aid in understanding the future-past. This paper has presented a proposal for arranging some 3D presentations of the structures of the cultural heritage. 3D modelling in archaeology is not a recent phenomenon. In fact, it has been practised for digital conservation systems and predictive modelling of archaeological objects and architectures in the last three decades. Some papers have been published in this regard. As author, we published a couple of research papers [4, 5] in this regard. It is submitted that this paper can be considered as one of the in-depth introductory research where a digital initiative has been made. A chapter of PhD dissertation has been completed on 3D conservation of cultural heritage site [3].

Generating 3D modelling of this paper is not the first attempt. Previously P.R. Myer in 1961 and M.A. Naqi et al. in 1999 published two papers where they tried generating 3D modelling of the central temple of Paharpur Vihar. Myer and Naqi both have imagined the ruined structure central structure as a stupa. Developed the idea by following Nalanda and Pagan stupa architecture, and Naqi et al. characterised the structure based on the Hindu temples of Eastern India and Ananda Temple of Pagan. They failed to be philosophising the structure. They tried to follow the ground plane to erect the rest of the ruins and tried to compare the style with the nearby references of the stupa.

The purpose of the 3D modelling of *Somapura Mahavihara* is to revisit the logical historical predictive explanations. K.N. Dikshit compared *Somapura Mahavihara* with a four-faced *chaumukha* Jain temple, i.e. Guhanad Jainvihara in Arhats. S.K. Saraswati tried to compare it with a *Sarvatobhadra* style of the temple [9]. Ali Naki and his team compared the style with that of *Barabudur* and *Angorkot* Temple, regarding structural, morphological similarities, and they developed the first 3D of *Somapura Mahavihara* [10]. Seema Hoque and M.M. Hoque explain the stylistic and teleological comparison with the *Vajrayana* Style. Basically, for generating the predictive 3D model of *Somapura Mahavihara*, a logical understanding of the *Vajrayana* style was necessary; and to determine the monumental architecture, the *Vastu Purusha Mandala*, discussed by Kautilya, was taken as the stylistic

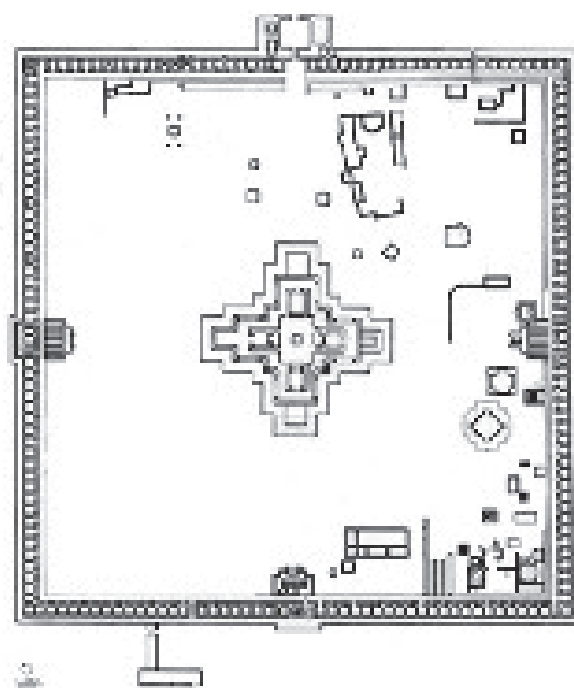


Figure 3.
 The ground plan of *Somapura Mahavihara*, Paharpur [8].

background [9]. The study of the ground plan of the central shrine of *Somapura Mahavihara* (Figures 3 and 4), shows that this *Mahavihara* may have belonged to the *Yantra Vajrayani* theology. Because of this ground plan of the central shrine of *Somapura Mahavihara*, which is published in the excavation report by Dikshit [8]. The sixtythree sculptures are noted in every corner of the basement (Figure 5). Along with only one Buddha sculpture, there were other sculptures of Hindu deities (e.g. the Yamuna, Krishna and Radha, Indo, Brahma, Siva) which were recorded.

Vajrayana introduced the polytheism theory of five *Dhyani* Buddhas as embodiments of five *Skandhas* or cosmic elements. The five cosmic elements are: *form* (*Rupa*), *sensation* (*Vedana*), *name* (*Samjna*), *conformation* (*Samskara*), and *consciousness* (*Vijnana*).

In *Vajrayana* mythology, the five cosmic elements are given anthropomorphic forms as *Pancha Dhayni* Buddhas. Each *Dhyani* Buddha is one aspect of the *Sunya*. These are *Vairochana*, *Ratnasambhava*, *Amitabha*, *Amoghasiddhi*, and *Akshobhya*. According to *Vajrayana* philosophy, these five *Dhyani* Buddhas are placed in five directions, i.e., *Vairochana* is in the centre, he is always placed in the sanctum of the stupa, *Amoghasiddhi* at the north, *Ratnasambhava* at the south, *Amitabha* at the

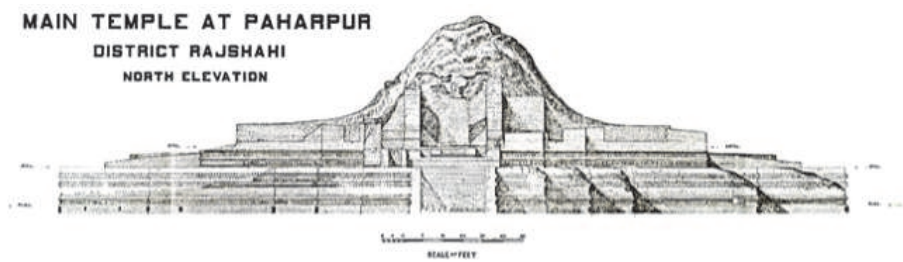


Figure 4.
2D model of Somapura Mahavihara generated by Dikshit [8].



Figure 5.
Ground plan of the central shrine of Somapura Mahavihara [8].

west, and *Akshobhya* at the east. The **Figure 6** is showing the *Garbhadhatu* mandala, is representing the *Vairocana* Buddha surrounded by eight Buddha and bodhisattvas (clockwise from top: *Ratnaketu*, *Samantabhadra*, *Samkusumitaraja*, *Manjusri*, *Amitabha*, *Avalokitesvara*, *Dundubhinirghosa*, *Maitreya*).

As a Structural Principles for Generating the 3D Model of Mahavihara, here the basic principles of Vastu Shastra are applied in constructing buildings, i.e., residential buildings, commercial complexes, industry layouts, towns, temples. The Vastu Mandala always follow five basic principles, which are: *Bhu Pariksha* (Examination and Selection of Site), *Dik Nirnaya* (Orientation), *Padavinyasa* (Planning of various component), *Manna* and *Ayadi* as Proportion and Measurement of building, and *Bhulambamana* or *Chanada* as the aesthetics of the building.

As an archaeological structural reference for generating the 3D model of the central shrine of *Somapura Mahavihara*, which is a Bronze votive stupa from the Ashrapur (**Figure 7**) [11] and Shallban Vihara (**Figure 8**) [13]. These evidence also represent the same kind of structure, a bell-shaped stupa in the centre and images of Buddha facing four cardinal points in the niches having *Bhadra* type of superstructure. T.K. Biswas [14] mentioned that near Paharpur vihara is Tara complex, conceded several votive stupas. However, these days, those votive stupas references have not been found in the register. If we go through the Easter Indian votive stupa references, there are a couple of examples that might complement the conceptual framework of the central structure of Paharpur, which are Saranath (**Figure 9**) and Bodhgaya (**Figure 10**). These references could be a replica of the evolved form of stupas constructed in the 7th century onwards. This type of replica was also found from various Buddhist sites at Mainamati during excavation.

Philosophising the Bangla regions' Buddhism and understanding the existing vihara structure to negotiate the prediction of *Somapura Mahavihara*. Here archaeological evidence has been referenced to justify the negotiation of Predictive 3D Modelling. Technologically a journey has been set from AutoCAD for 2D drawing to



Figure 6.
Garbhadhatu mandala (de.wikipedia.org/w/index.php?title=Datei:Mandala1_detail.jpg&filetimestamp=20041210200904).



Figure 7.
Bronze votive stupa, Ashrafpur [11].



Figure 8.
Bronze votive stupa, Shallban Vihara [12].



Figure 9.
Votive stupa from Saranth [14].

3D Max for 3D modelling, and then Mudbox, Unity3D, Adobe Photoshop, and Illustrator are used here to finalise the VR. Generating the 3D modelling and VR project have been negotiated in two different ways. First one, the existing ruins of Vihara of Paharpur has been generated, which can be considered as known to know journey and the final project is predictive 3D modelling, which can be told as known to predictive journey.

4. 3D model of surviving structure of central shrine of Somapura Mahavihara

To generate the Predictive 3D modelling and VR of *Somapura Mahavihara*, it is important to develop the 3D Model and VR of the remaining structure. Warfare also caused the cultural heritage safeguarding by a transnational agency like UNESCO as a world patrimony. Then, the first UNESCO convention has occurred in 1974. These days, the world entered the horrific blood-shedding. Religious, ideological reasoning to trigger this destructive setting and found the cultural evidences as an ideologically conflicting entities. These have been destroyed by shelling. Subsequently, natural disasters (e.g., earthquake) caused erase the human creative genius of archaeological evidences permanently. Therefore, London Charter and Seville Principles are initiated to conserve and safeguarding the cultural heritage digitally. The



Figure 10.
Votive stupa from Bodhgaya [14].

basic principle is to preserve the existing structures without add any changes. It is a known to know journey to save and visualise the cultural heritage digitally. The following **Figures 11–17** are generated based on the existing structure of Paharpur Vihara or *Somapura Mahavihara*.

5. The final outcome of the predictive 3D modelling and VR of the central structure of Paharpur Vihara

Going with the aforesaid logical background, the following predictive 3D model has been developed. Shown here is the ground plan to develop the structure morphologically using the *Yantra Vajrayana* Mandal as the ideal to erect the predictive 3D model of *Somapur Mahavihara*. Specially the top structure has been generated based on the votive stupas, which have been discussed in previous section (**Figures 7–10**). According to structural engineering, the arch-like technics

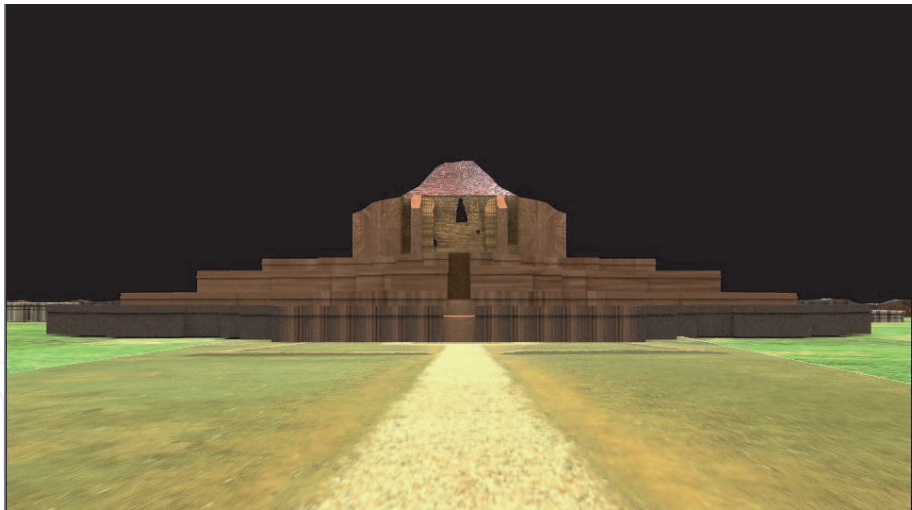


Figure 11.
3D model of the front view of the resented structure of Somapura Mahavihara, Paharpur.

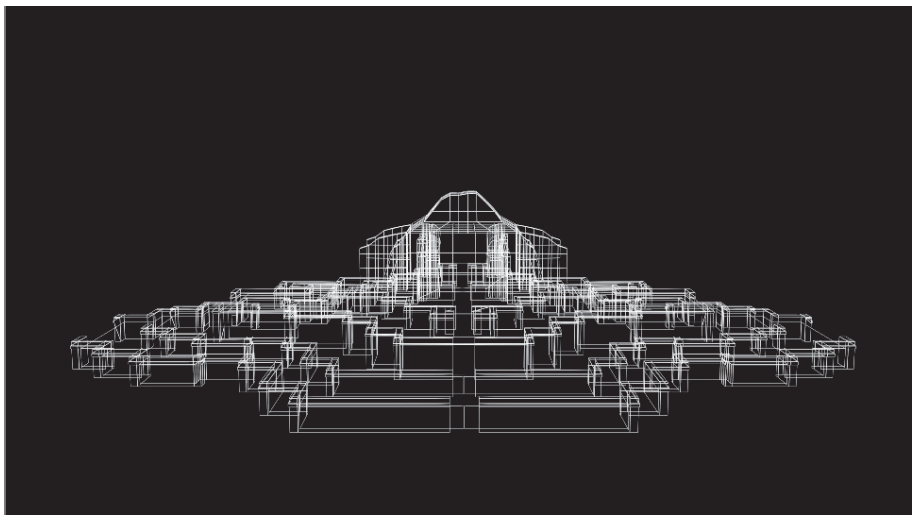


Figure 12.
Wire frame for generating the 3D model of the central shrine of Somapura Mahavihara, Paharpur.

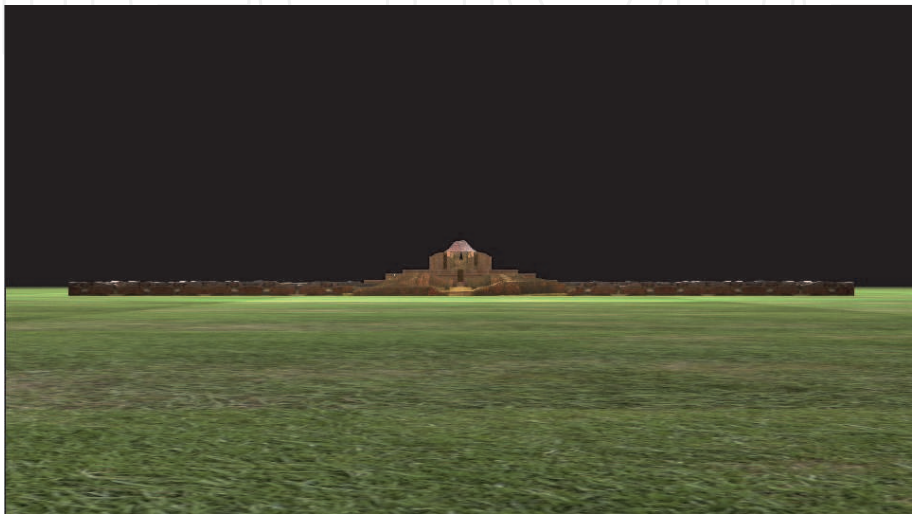


Figure 13.
Long view of the 3D model of existing Somapura Mahavihara, Paharpur.

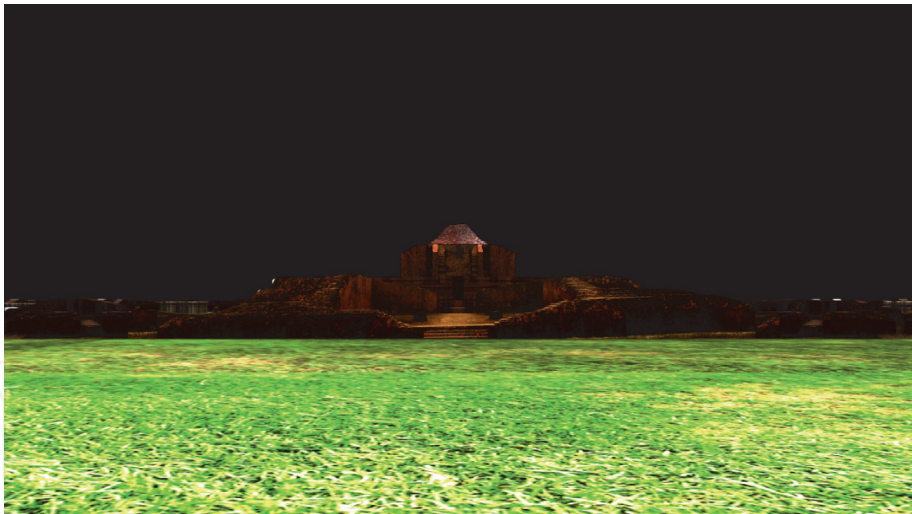


Figure 14.
Close view of the 3D model of Somapura Mahavihara, Paharpur, with central entrance.

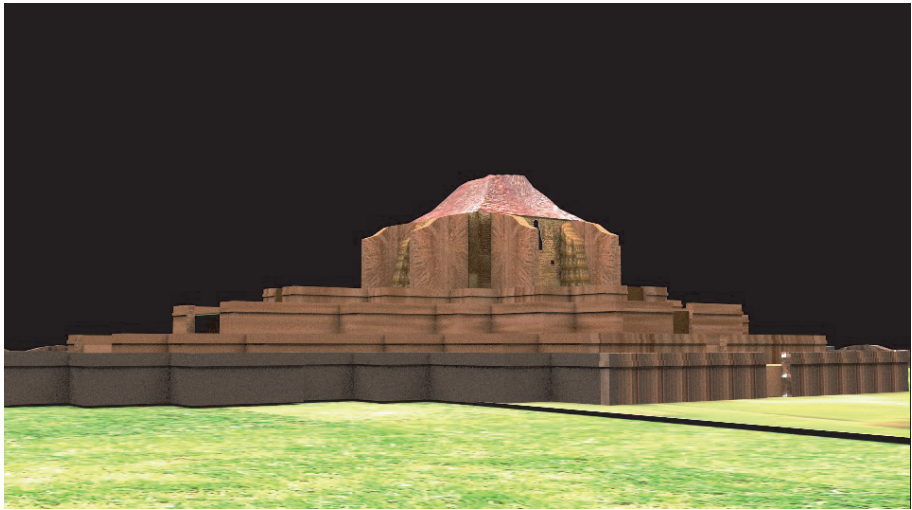


Figure 15.
Mid shot of the central shrine of the Somapura Mahavihara, Paharpur.

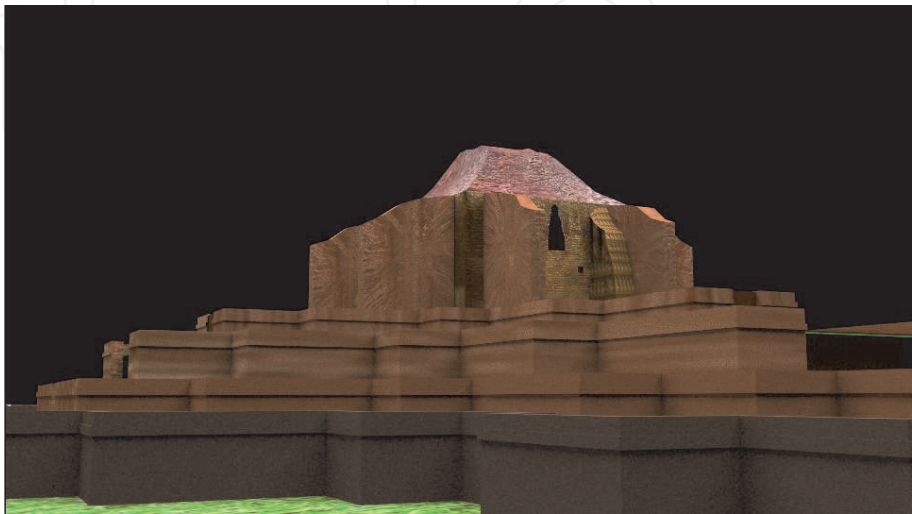


Figure 16.
Partial close view of the central shrine of the Somapura Mahavihara, Paharpur.

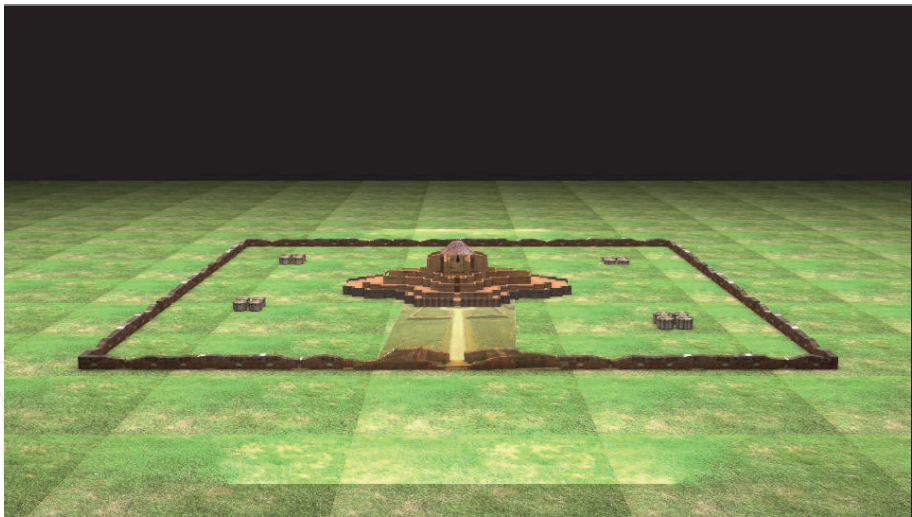


Figure 17.
Top view of the 3D model of the Somapura Mahavihara, Paharpur (source: The author).

corbelled method has been massively followed. It is the spanning of a space or void of structure. Particularly to support the superstructure roof, here corbelled techniques have been used. There are several small-scaled corbelled arches (**Figure 18**) have been found after excavating the paharpur [8]. By following the ground plane and existing vertical central structure, the prediction of 3D modelling has been generated in the paper. The logical framework of this modelling has been following the *Vajrayana* Buddhism, which elaborated in the previous section of this paper. The outcome of the predictive 3D models and VR of the central structure of Paharpur Vihara or *Somapura Mahavihara* is following below (**Figures 19–26**).

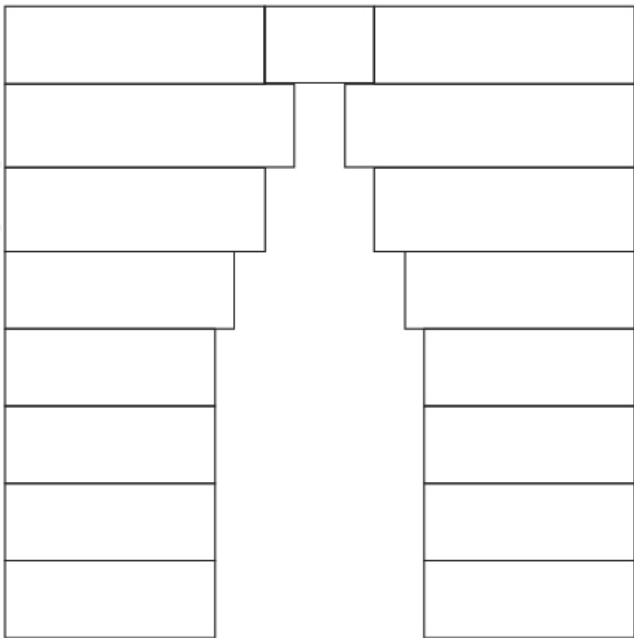


Figure 18.
Design of corbel arch.

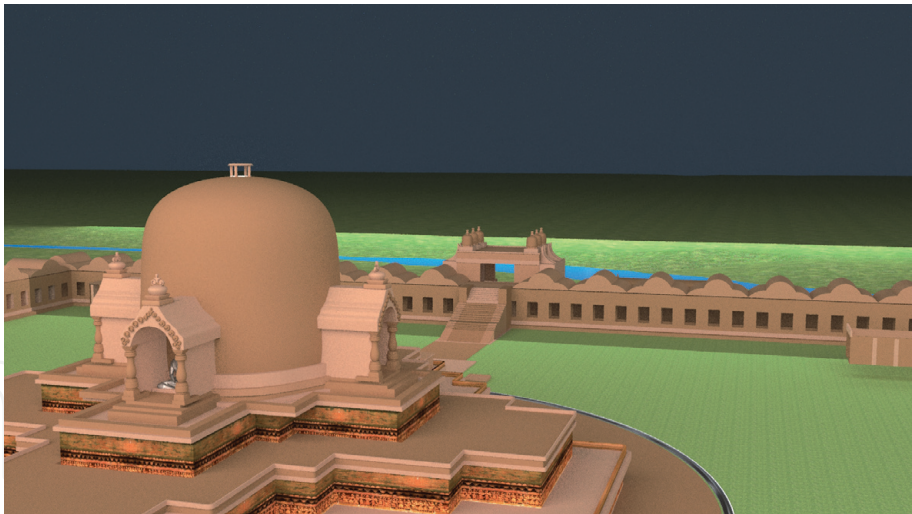


Figure 19.
Partial view of predictive 3D model of the central structure of the Somapura Mahavihara, Paharpur.



Figure 20.
Partial top view of the predictive 3D model of the Somapura Mahavihara, Paharpur.

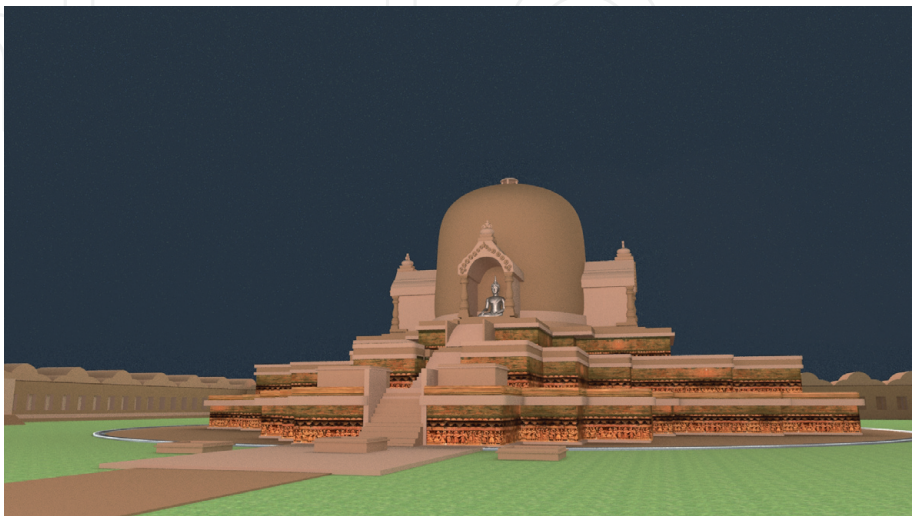


Figure 21.
Front view of the predictive 3D model of the central shrine of the Somapura Mahavihara, Paharpur.

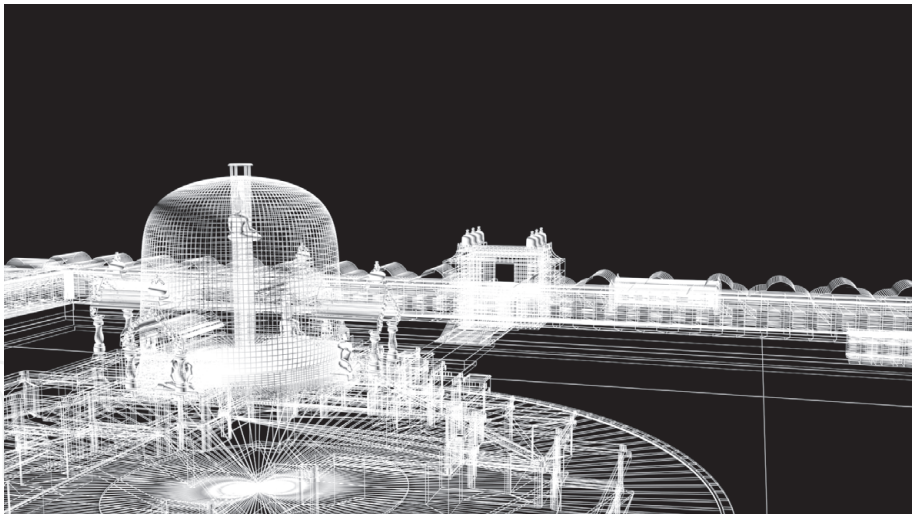


Figure 22.
Wire frame of the central gateway of the predictive 3D model of the Somapura Mahavihara, Paharpur.

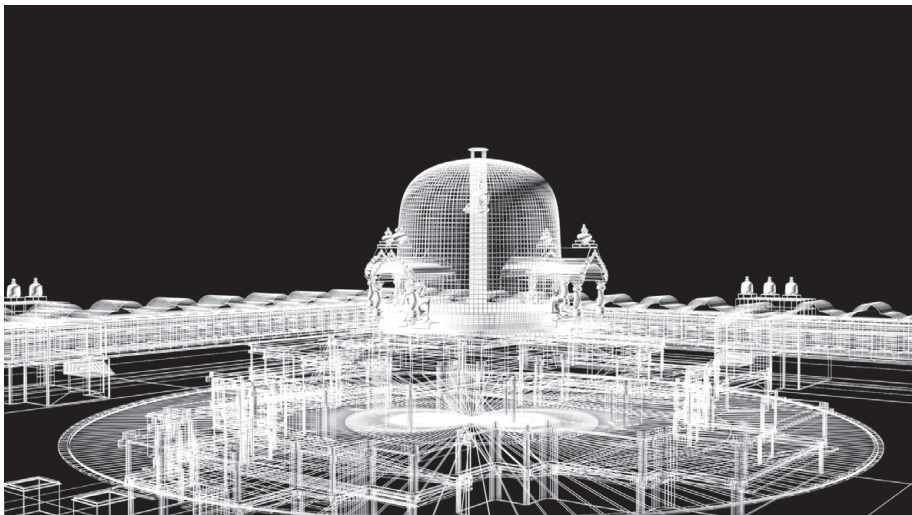


Figure 23.
Wire frame of partial view of predictive 3D model of the central shrine of the Somapura Mahavihara, Paharpur.

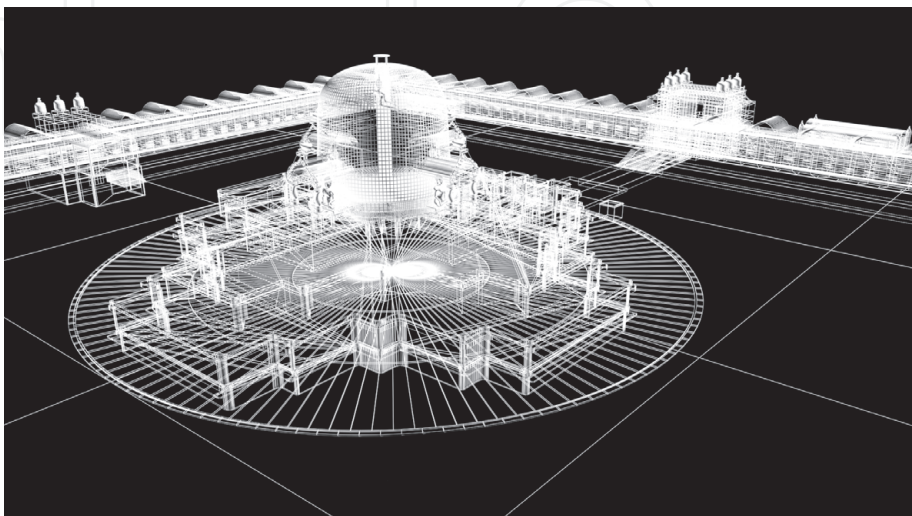


Figure 24.
Wire frame of the horizontal view of the predictive 3D model of the Somapura Mahavihara, Paharpur.

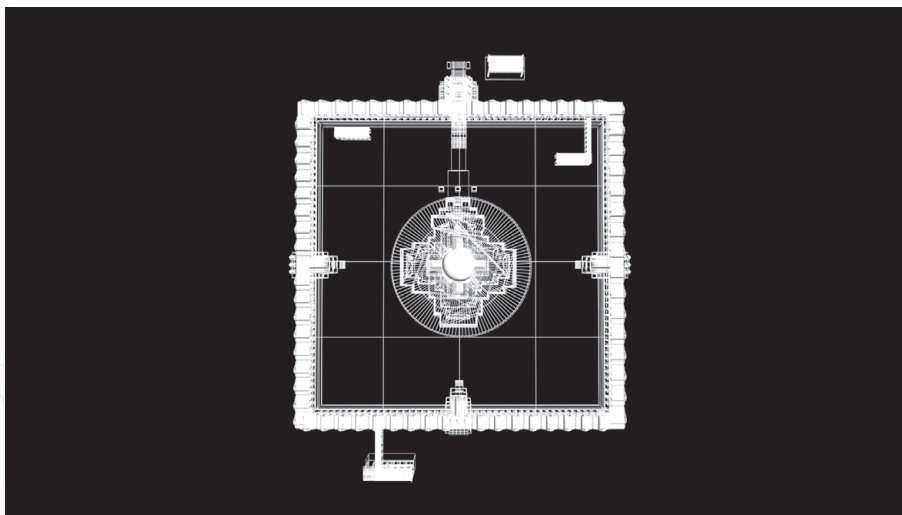


Figure 25.
Wire frame of the vertical view of the predictive 3D model of the Somapura Mahavihara, Paharpur.



Figure 26.
Top view of the predictive 3D model of the Somapura Mahavihara, Paharpur (source: The author).

6. Conclusion

Vajrayana Buddhism philosophised the yantra mandala style of vihara of Paharapur in this paper, and structurally Votive Stupas, notably, Shallbanvihar, Ashrafpur, Saranath, and Bodhgaya phenomenally characterised the superstructure of this vihara. The discovered Votive stupa belongs to the Vajrayana Buddhism. The **Figures 19–26** are the logical interpretation of the Vajrayana style. Meanwhile, a question has been raised inquiring into the real necessity to regenerate these structures virtually. The answer is: yes, it is vital for a better understanding of accuracy and preservation capability. A case in point is the predictive 3D modelling of Paharpur Vihara has been generated on the idea of Yantra Mandala and the central shrine predicted on the notion of Vajrayana. Heritage sites are continuously exposed to threats such as weathering erosion and anthropogenic erosion, and especially, the problematic safeguarding mechanism [15]. Therefore, it is necessary to conserve the Paharpur Vihara or *Somapura Mahavihara* digitally and visualised by using VR.

IntechOpen

Author details

Md. Masood Imran^{1*} and Miner Masud²

1 Department of Archaeology, Jahangirnagar University, Dhaka, Bangladesh

2 Institute of Information Technology, Jahangirnagar University, Dhaka, Bangladesh

*Address all correspondence to: masoodimranmannu@juniv.edu

IntechOpen

© 2021 The Author(s). Licensee IntechOpen. This chapter is distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/3.0>), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited. 

References

- [1] Martin, M. 1838. *The History, Antiquities, Topography, and Statistics of Eastern India*. First, Vol. London: Wm. H. Allen and Co. Leadenhall-Street.
- [2] Alam, M. S. 2012. "Paharpur." *Banglapedia*. Bangladesh Asiatic Society. <http://en.banglapedia.org/index.php/Paharpur>.
- [3] Imran, Md Masood. 2019. "'Safeguarding-Governmentality' of the Cultural Heritage: Democratising, Conserving, and Representing the Past(s) of Bangladesh." *Hiroshima University*. <https://ir.lib.hiroshima-u.ac.jp/en/00048445>.
- [4] Imran, Masood, and Minar Masud. 2016. "Keeping Alive the Sultanate Past of Bangladesh by Using 3D Modelling and Virtual Reality as Tools for Assisting Archaeology and Generating the Predictive Models of World Cultural Heritage Sites — The Case Study of Town and Mosques of Shait Gumbad Mosque Re." *Pratna Samiksha: A Journal of Archaeology* 7: 161–89. https://www.researchgate.net/publication/309857794_Keeping_Alive_the_Sultana te_Past_of_Bangladesh_by_Using_3D_Modelling_and_Virtual_Reality_as_Tools_for_Assisting_Archaeology_and_Generating_the_Predictive_Models_of_World_Cultural_Heritage_Sites-The_C.
- [5] Imran, Md Masood, and Minar Masud. 2021. "Virtual Heritage of the Saith Gumbad Mosque, Bangladesh." *Advances in Intelligent Systems and Computing* 1309: 417–29. https://doi.org/10.1007/978-981-33-4673-4_33.
- [6] Imran, Masood. 2018. "'Banalism': Ownership of the Past in Bangladesh." *Bangabidya: International Journal of Bengal Studies* 10: 446–67. https://www.researchgate.net/publication/323275472_Banalism_Ownership_of_the_Past_in_Bangladesh.
- [7] UNESCO World Heritage Centre. 1985. "Ruins of the Buddhist Vihara at Paharpur." UNESCO. 1985. <https://whc.unesco.org/en/list/322/>.
- [8] Dikshit, K. N. 1999. *Memoirs of the Archaeological Survey of India. Excavations at Paharpur, Bengal*. 1999th ed. New Delhi: The Director General, Archaeological Survey of India Janapath.
- [9] Hoque, S., Hoque, M. M. 2004. "Understanding the Paharpur Temple Architecture in New Perspective." In *Proceedings of the International Seminar on Elaboration of an Archaeological Research Strategy for Paharpur World Heritage Site and Its Environment (Bangladesh)*, edited by M. S. Alam, 58–66. Dhaka: Dept. of Archaeology, Ministry of Cultural Affairs, Govt. of the People's Republic of Bangladesh and UNESCO Dhaka.
- [10] Naqi, M.A., Falguni, M. 2004. "Form and Morphology: A Conjectural Virtual Reconstruction." In *Proceedings of the International Seminar on Elaboration of an Archaeological Research Strategy for Paharpur World Heritage Site and Its Environment (Bangladesh)*, edited by M. S. Alam. Dhaka: Dept. of Archaeology, Ministry of Cultural Affairs, Govt. of the People's Republic of Bangladesh and UNESCO Dhaka.
- [11] Saraswati, S.K. 1976. *Architecture of Bengal (Ancient Phase)*. Book 1. First. Calcutta: G. Bharadwaj.
- [12] Ghos, Suchandra. 2016. "Mainamati: An Enigmatic Centre of Buddhism in Southeastern Bangladesh." In *Nalanda, Srivijaya and Beyond: Re-Exploring Buddhist Art in Asia*, edited by Gauri Parimoo Krishnan, 37–50. Singapore: Asian Civilisations Museum. https://www.academia.edu/32345899/Mainamati_An_enigmatic_Site?auto=download.

[13] Rashid, M. H. 1997. The Early History of South-East Bengal in the Light of Archaeological Material. First. Dhaka: Itihash Academy.

[14] Biswas, T. K. 1989. "Sculptured Stupas in Medieval Eastern India." In Studies in Arts and Archaeology of Bihar and Bengal, edited by G. mitra, D., Bhattacharya, First, 85–89. Delhi: Sri Satguru Publications (A Division of Indian Books Centre).

[15] Ahsan, S. M. K., Palash, W., Roy, J. S., Imran, M. M. 2004. "Looking through the Water Logging Problem of Somapura Mahavihara, Paharpur: An Evaluation of Existing Drainage System." In Preceding of the International Seminar on Elaboration of an Archaeological Research Strategy for Paharpur World Heritage Site and Its Environment (Bangladesh), edited by M. S. Alam. Dhaka: Dept. of Archaeology, Ministry of Cultural Affairs, Govt. of the People's Republic of Bangladesh and UNESCO Dhaka.